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Project Summary

Long-Term Effects of the Barge *Florida* Oil Spill

Howard L. Sanders, J. Frederick Grassle, George R. Hampson, Linda S. Morse, Susan Garner-Price, and Carol C. Jones

Intensive sampling of marine and estuarine benthos was conducted over a 5-year period after a spill of No. 2 fuel oil by the barge *Florida* off West Falmouth, Massachusetts, on September 16, 1969. Samples were taken along an onshore-offshore gradient of pollution, and control samples were taken from unoiled sites. Analyses of hydrocarbons established that pollution was greatest and most persistent in the intertidal and subtidal zones of Wild Harbor River and less severe in degree and duration at stations farthest from shore. A variety of concurrent analyses showed that disturbance of the fauna was most severe and longest lasting at the most heavily oiled sites and less severe but perceptible at lightly oiled stations. Patterns of disturbance were not related to granulometry of the sediments. Plants, crustaceans, fish, and birds suffered both high mortality immediately after the spill, and physiological and behavioral abnormalities directly related to high concentrations of the fuel oil. Five years after the spill, its effects on the biota were still detectable, and partly degraded No. 2 fuel oil was still present in the sediments in Wild Harbor River and estuary.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, Ohio, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

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Introduction

Early on the morning of September 16, 1969, the barge *Florida* ran aground on a rocky shoal off Fassett's Point, West Falmouth, Massachusetts, and spilled 650,000 to 700,000 liters of No. 2 fuel oil into Buzzards Bay (Figures 1-3). Strong south southwest winds, common to this regoin, churned the oil into an oil-water emulsion and drove it northeastward into Wild Harbor River in North Falmouth. The oil spread over more than 1,000 acres, including 4

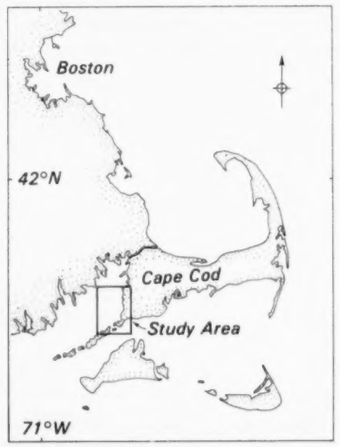

Figure 1. Map of Southeastern Massachusetts showing location of study area in Eastern Buzzards Bay

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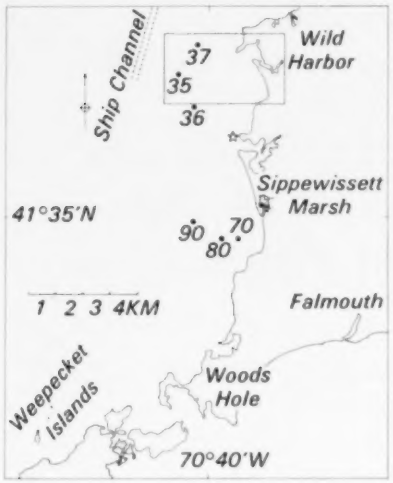

Figure 2. *Map of study area showing site of grounding of the barge* Florida *(star) and major clusters of sampling sites. Intensively sampled area in box.*

miles of coastline. Mass mortality of at least the larger marine animals quickly supervened in the intertidal and subtidal zones of the river.

Water-based emulsifiers, claimed by the manufacturers to be nontoxic, were initially used to clean up the oil. The company hired to remove the oil first applied these emulsifiers in Wild Harbor on the evening of September 16; further applications were made the next day. On September 18 and 19, the company introduced emulsifiers into the waters from the beach south of Wild Harbor before being restrained on the grounds that they were toxic to shellfish. A total of 17,072 liters of emulsifiers were

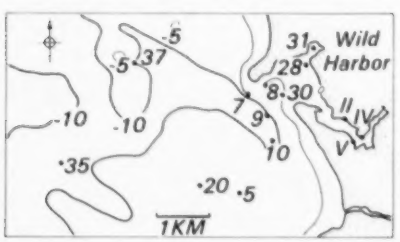

Figure 3. *Intensively sampled Wild Harbor River area, showing location of stations and bathymetry. Contour interval is 5 meters.*

added to the water in fewer than 4 days. These chemicals were not the chief cause of death, however, for animals had begun to die in large numbers at least 4 hours before the first emulsifiers were applied. Most spills of petroleum distillates result in a significant kill of marine life if they are of any magnitude.

Several observations were made during the initial study period. Within only 8 to 10 days at the relatively high temperatures of 18° to 21°C, carcasses of most soft-bodied animals completely decomposed. Skeletons were soon disarticulated and scattered. Both intertidal and subtidal sediments, particularly sands, became physically unstable, probably because of disintegration of animal secretions and tubes, and the death of vegetation and benthic algae that bound the sediment. Marsh grasses reached by waterborne oil during the first 3 weeks after the spill died. The pollution indicator polychaete *Capitella* increased explosively to occupy the river bottom in very dense concentrations. By late spring and early summer of 1970, the numbers of this polychaete crashed, and a few other species were able to occupy this area. In the spring of 1970, the gonads of blue mussels (*Mytilus edulis*) surviving in the affected area were thin and sterile, whereas gonads of blue mussels in the unpolluted Sippewissett Marsh were plump and fertile. Some mortality always attended the presence of oil in the sediments, and the greater the concentration of oil, the heavier the mortality. In sediments saturated with oil, the extinction of life was sometimes nearly complete.

To study spatial and temporal changes in the concentration and composition of the fuel oil and in the density and character of the benthic fauna, a long-term strategy was developed. The strategy involved monthly or bimonthly sampling at stations along a gradient ranging from the most severe effects in Wild Harbor River to the least severe effects at offshore stations in Buzzards Bay. For the intensively sampled stations, we considered granulometry of sediments, composition of hydrocarbons, and quantitative and qualitative changes in the fauna (including patterns of dominance, constancy, numerical variability, and diversity).

The report purposely emphasizes details to avoid the error of many pollution-related studies of benthic ecology that draw their conclusions based on equivocal interpretations of insufficient and ambiguous data. Such inadequate conclusions are often the basis for important decisions. Our detailed presentation and analysis of the data aims to demonstrate more than adequately the persistent deleterious effects of No. 2 fuel oil on the marine benthos.

Conclusions

1. The petroleum hydrocarbons in the sediments of Wild Harbor River and adjacent offshore came from the No. 2 fuel oil spilled by the *Florida* on September 16, 1969. Concentrations were highest and degradation slowest in the intertidal and subtidal zones of the river. Concentrations were lowest at stations farthest from the shore.

2. Oil spread seaward from the areas of highest concentrations for at least 5 years. After this span of time, fuel oil that was only somewhat degraded was still detectable in the peat and sediments of the river.

3. Within 12 hours after the spill, marine animals began to die in great numbers. Increased mortality rates were most severe and long lasting in the river, less so at nearshore subtidal stations, and least of all at the more distant offshore stations. This pattern was especially evident among ampeliscid amphipods.

4. The opportunistic polychaete *Capitella* monopolized the biologically denuded substrata at the heavily oiled stations for the first 11 months after the spill, then crashed. At the offshore stations, *Mediomastus ambiseta* (another capitellid polychaete), became common nearly a year after the spill and remained so during the second year at intermediately oiled stations; however, it soon declined in numbers at lightly oiled stations.

5. Intensity and duration of faunal changes matched the gradient of pollution by No. 2 fuel oil, but they were only occasionally related to granulometry of the sediments.

The fauna in Wild Harbor River was unstable in density, diversity,

and composition. Fluctuations in composition were successional. After more than 5 years, the fauna there had only slightly recovered.

At the nearshore subtidal stations, faunal fluctuations were rapid and very broad in the first year, and successively less so in later years. After the first year, changes in composition began to alter in character from successional to season. Recovery had begun, but it was not very far advanced by the end of 2½ years.

Faunal changes at stations farthest from shore were relatively slight and seasonal in nature. The fauna recovered in density, number of species, and diversity after about a year.

At unoiled stations, faunal changes were slight and seasonal.

6. Increased species richness usually contributed more to recovery of diversity than did increase in the evenness with which individuals were distributed among species.

7. Even though the fauna began to recover in diversity and density, they continued to suffer the ill effects of the oil. Physiological and behavioral disorders caused by the oil resulted in growth and reproduction impairment, and death.

8. Bacterial seeding in areas heavily polluted by oil is probably inadequate to hasten the degradation of petroleum hydrocarbons.

9. Faunal surveys undertaken more than a week after an incident of oil pollution probably will not find any of the larger, soft-bodied animals killed by the oil.

10. Carefully conducted, quantitative, long-term studies, to detect physiological and behavioral effects of oil spills on all levels of the marine trophic structure (the apical member of which is often man) are essential. Only through such studies can society appreciate the true price paid for the undramatic, pervasive, ever-spreading, chronic pollution that disrupts and alters increasingly great reaches of natural habitats. Mathematical techniques (particularly diversity indices) must be used with comprehension and care.

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***John S. Farlow** is the EPA Project Officer (see below).*

The complete report, entitled "Long-Term Effects of the Barge Florida *Oil Spill," (Order No. PB 81 144-792; Cost: $17.00, subject to change) will be available from:*

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